

## TRANS-URETERO-URETERAL ANASTOMOSIS.

I—INTRAPERITONEAL. II—RETROPERITONEAL. (a) ANTERIOR TO AORTA AND VENA CAVA; (b) POSTERIOR TO AORTA AND VENA CAVA.

BY NORVELLE WALLACE SHARPE, M.D.,

OF SAINT LOUIS, MO.

I. *History of Ureteral Anastomosis.*—One of the earliest operations, if not actually the pioneer case of ureteral anastomosis, was made by Simon, of St. Thomas' Hospital, London, in 1851, in an effort to extraperitoneally anastomose the ureters into the rectum. Nussbaum followed the method of Simon in 1876; also Smith in 1879. Most of the early attempts were made for the relief of vesical extrophy. Gluck and Zeller were among the early experimenters on animals. In 1886 Schopf,<sup>23 24</sup> a German, and Poggi,<sup>30</sup> an Italian, within a few days of each other performed an end-to-end anastomosis, though by different methods. Much experimentation on animals now developed in the years following this notable advance. Budinger in 1896 endeavored, on animals, to duplicate previous work, but with fatal results. Tizzoni and Poggi removed the entire bladder; a new receptacle was formed from an intestinal loop, and the ureters were implanted therein. In 1892 the technique of Van Hook was published. In 1897 Bovée, in reporting a personal case, collected 12 cases of ureteral anastomosis from the literature, two of which must however be discarded. He materially modified the method of Van Hook. The following method classification of uretero-ureteral anastomosis, together with exponents of each method, tabulated by Markoe and Wood<sup>25</sup> is excellent:

- I. Transverse end-to-end. { (a) Without support. Schopf, Hoch-  
enegg, Cushing.  
(b) With support, Tauffer.

## II. Oblique end-to-end. Bovée.

- III. Invagination. { (a) Without support. (1) Ureter not split.  
Poggi.  
(2) Ureter split to invaginate. Mayo Rob-  
son, Winslow.  
(b) With support. Markoe.

## IV. Lateral implantation. Van Hook, Kelly, Emmett, Doherty.

No inconsiderable ingenuity has been displayed in the effort to overcome the hiatus caused by an excessive loss of ureteral substance. Thus Bovée,<sup>20</sup> based upon successful experimental work on two dogs, advises dislocation of the kidney downward, with suturing in its new bed subsequent to the completed anastomosis. Monari believes that the ureter may be attached to the abdominal wall under considerable tension, and when time has produced the required length, a lateral anastomosis may be attempted. Rydygier suggests implanting the severed ends on the abdominal wall and connecting them by a duct lined with skin; while Van Hook would elevate a flap from the bladder, develop a diverticulum and so bridge over the space to the proximal end of the ureter.

At the close of this chapter of ureteral surgery none of these suggestions had been performed on man; and the choice rested between implantation into the bladder, bowel, or skin.

II. *Anatomy of the Ureter.*—For an exhaustive study of the anatomy of the ureter search must be made through various monographs which discuss the theme. The following points will, however, prove germane to the subject in hand, and will be helpful in the final analysis: The adult ureter ranges from 25 to 40 cm. in length, while the outside diameter may be said to be 3 to 4 mm.; yet the fact remains that both the outside diameter and lumen vary considerably owing to curvings and sacculations that are fairly constant. The course of the ureters is not regular nor symmetrical. So far back as 1869 Freund and Joseph<sup>27</sup> showed that the left ureter is nearer the mid-line and as a rule nearer the uterus and its cervix. Crossing the common iliacs they are from 5.7 to 7 cm. apart; then following the pelvic curve they separate until

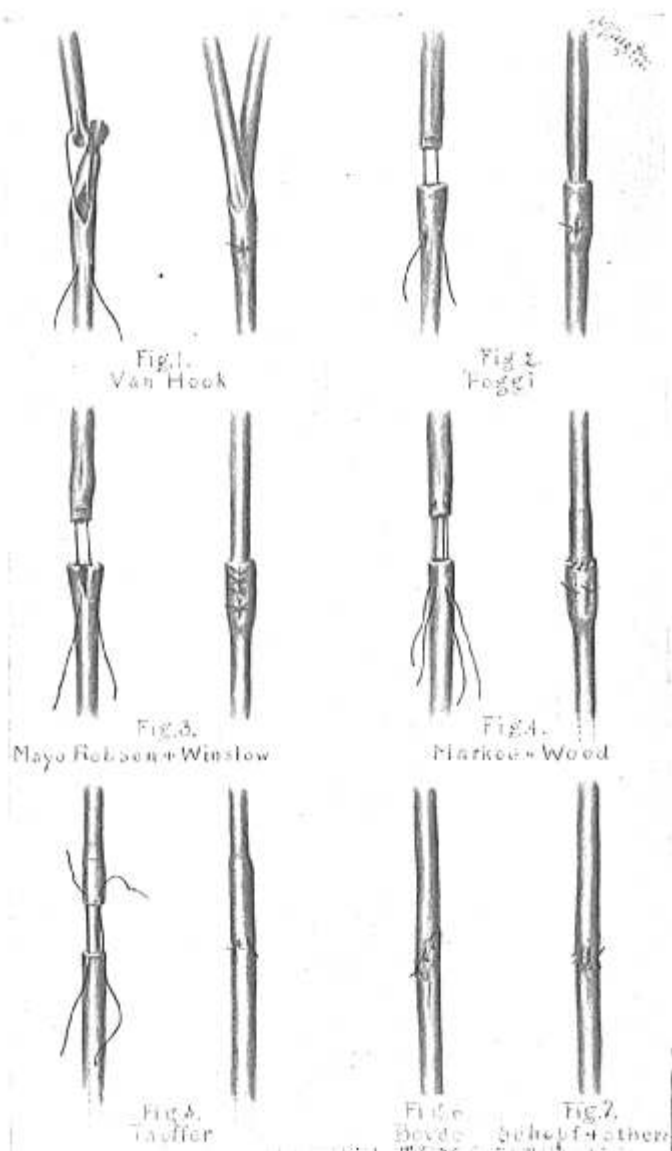


PLATE I.—Various methods of ureteral anastomosis, with their advocates.\*

\* Dr. Mills has here portrayed certain steps and the end results of actual anastomoses of the human ureter made by him for this plate. It is probable that, even with the reduction necessary to make a full-page plate of the ANNALS OF SURGERY, the dimensions will remain slightly in excess of the normal ureter.

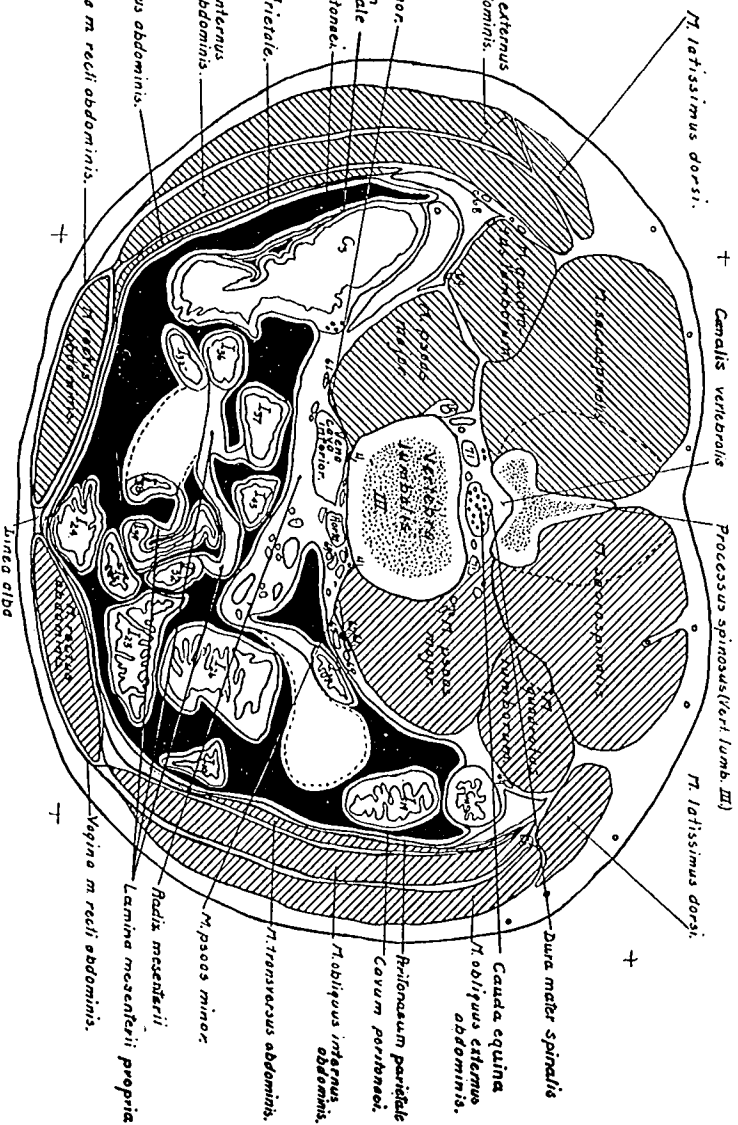


PLATE II.—4. N. sympathetica. 61. Ureter. 65. V. mesenterica inferior. 67. A. and V. spermatica interna. 68. N. thoracica XII. 69. N. lumbalis I. 70. N. lumbalis II. 71. N. lumbalis III. 73. N. lumbalis IV. 74. N. obturator. 75. N. cruralis anterior. 77. Chorda lumbosacralis. 78. N. sacralis I. 79. N. sacralis II. 80. N. sacralis III.

\* For the use of Plates II, III, IV, and V, I am indebted to the courtesy of Dr. Peter Potter, Associate Professor of Anatomy, medical department of St. Louis University. These plates are direct tracings from transverse sections of the human body of the thickness of a vertebra: portion of an admirable series made by Dr. Potter and published "Topography of the Thorax and Abdomen," "University of Missouri Studies," Columbia, Mo., 1905. The additional notations made above hold good throughout the four plates.

2 to 3 cm. below the iliacs, from 10 to 13 cm. intervenes; at line of the internal os, 9.8 cm. apart; on entering the bladder, 2.7 to 3.5 cm. apart. The distance between the external os and the right ureter, 2.5 to 3.3 cm.; the left ureter, 1.5 to 2.7 cm. Luschka<sup>28</sup> and Holl<sup>29</sup> give measurements which vary somewhat from the above, but agree as to the asymmetry ordinarily encountered. Quenu and Duval have suggested as a valuable landmark in identifying the lower ureter the bifurcation of the common iliac artery. The right ureter will be found 1 cm. external to the bifurcation and crosses the iliac vertically, while the left ordinarily is exactly upon the bifurcation. The ureter is composed of three layers. The outer coat is fibrous; the middle coat is muscular, whose thin smooth longitudinal folds manifest some tendency to stratification; the intima is mucous. The muscular coat, inducing a fairly rhythmic peristalsis, is assisted by the force of gravity in establishing the cloacal function of the ureter. Waldeyer<sup>30</sup> has directed our attention to the fact that certain longitudinal bundles extend from the bladder out on the ureter. These are united by connective tissue, and separated from the ureter proper by a space which he considers a lymph-space. This sheath ranges from .5 to .75 mm. in thickness, and extends within the ureter from 3 to 4 cm. Disse, however, claims that these bundles do not arise from the bladder, as might be inferred, but from the ureter, and thinks it probable that their hypertrophic condition, together with the subjacent space, follows vesical contractions exerting traction on the outer ureteral coat. There is, in addition to this sheath of Waldeyer, a second fibro-muscular covering which, starting upon this structure and somewhat intimately blending with it, continues upward. Between this sheath and the ureter proper are found fine fibrous fascicles and adipose tissue, which as has been suggested by Sampson may subserve the function of a cushion protecting the ureter. It is a moot point as to whether true lymphatic spaces exist in this tissue. Sampson has also directed attention to the contractile mobility of the ureter within this sheath, its protective influence against inflammatory and malignant extension processes, and that within its

embrace is found the periureteral arterial plexus. The lymphatic system is well developed and found within the different layers. The blood-supply of the ureter is drawn from branches of the renal, spermatic, utero-ovarian, internal iliac, inferior mesenteric, middle hemorrhoidal and inferior vesical arteries; while its veins, with apparently no prevailing rule, empty into neighboring vessels. Disse has shown that the pelvis of the kidney draws its blood-supply from a branch of the renal artery which courses down over the abdominal ureter; this section also derives nourishment from the spermatic. The pelvic section owes its main supply to the middle hemorrhoidal and inferior vesical arteries. In general it may be noted that these trunks parallel the ureter, to which they are attached by connective tissue. From these parallels arise at comparatively frequent intervals branches which, piercing the muscularis, still further divide within the intima into longitudinal sub-branches found fairly constantly from the kidney to the bladder. Capillary systems to the epithelium and muscularis are the terminals of the arteries of the propria. From these systems the venous current is carried through a plexus, largely longitudinal, inside the muscularis. This venous plexus of the intima empties into channels within the adventitia, which parallel the arteries. Probably the most valuable of our anatomic assets of comparatively recent acquisition is the periureteral arterial plexus, whose orientation has been so felicitously accomplished by Sampson.<sup>31</sup> He has shown that from the aorta, the renal, ovarian, iliac, uterine, etc., arteries arise branches which may be styled uretero-subperitoneal arteries. These arteries ordinarily divide into two branches; first, an ureteral branch which helps to form the periureteral arterial plexus; second, a subperitoneal branch, which supplies the tissue contiguous to the ureter.

1. The ureteral arteries on reaching the ureter divide into ascending and descending branches, both paralleling the ureter and united to it by a loose fibrous tissue; a free anastomosis exists between the ascending and descending sub-branches. Thus, enveloping the ureter, is found a longitudinal arterial system, whose offshoots abundantly anastomose, extending

from the kidney to the bladder. From these large trunks smaller branches arise which imbed themselves somewhat more deeply in the perimuscular fibrous tissue of the ureter than do the stems; and these, too, anastomose, thus forming with the main trunks a periureteral arterial plexus extending the entire length of the ureter up over the pelvis of the kidney and still accompanying the ureter as it pierces the bladder-wall. From this plexus still smaller vessels arise which penetrate the walls of the ureter; and yet other channels are found which, leaving the ureter, supply the adjacent tissues, and even these may anastomose with branches of other vessels supplying these parts.

2. The subperitoneal divisions of the uretero-subperitoneal vessels supply the tissues adjacent to the ureter and also, in places, the peritoneum. These may anastomose with each other and with branches from neighbouring vessels including branches from the ureteral plexus, and thus may serve as a source of nourishment to the ureter. And yet other sources exist; for the uterine and vesical arteries of one side anastomose with those of the other, and in addition there is a free anastomosis between the uterine and ovarian arteries; and again the branches of the latter anastomose with branches from the renal. The periureteral arterial plexus thus is shown to receive its blood-supply from definite ureteral arteries, and may be nourished indirectly through the anastomosis of these arteries and branches from the plexus itself with the branches of vessels supplying the tissue circumjacent to the ureter.

Sampson has also shown that in the dog the ureter will withstand extensive manipulation even to stripping with the finger nail, or freeing throughout its entire length, and no untoward effect will follow provided a sufficient number of nutrient vessels remain intact to preserve the integrity of the ureter. [Of interest at this point is the record of Margaroucci<sup>82</sup> that he isolated the entire ureter in ten dogs; in none necrosis followed. He, too, explains this fact by the existing arterial supply with its numerous anastomoses. He claims that the supply from the renal artery alone is almost sufficient

to nourish the entire ureter. Durante<sup>88</sup> accomplished the same feat on a woman, where the ureter was involved in a gigantic cystadenoma of the broad ligament.] And on the other hand manipulation which destroys the periureteral arterial plexus even though far less severe than in the former instances, will as a rule, so impair the vitality of the ureter that necrosis will supervene. He concludes that when the integrity of the ureter is impaired, as by malignant invasion, and choice remains, resection with end-to-end anastomosis or a vesical implantation is preferable to any method which demands a stripping so severe as to imperil the function of the periureteral arterial plexus.

III. *Indications for Ureteral Anastomosis.*—The indications for an ureteral anastomosis are sufficiently obvious to justify the omission of special narration and discussion. In brief: 1. Any condition in an operative attack within the abdomino-pelvic area which necessitates an interruption of the continuity of the ureter will demand consideration for the restoration of the integrity of the urinary channel. 2. Operative casualties occurring within the abdomino-pelvic area which seriously impair or destroy the continuity of the ureter. 3. Any pathologic condition existing in the abdomino-pelvic area which so encroaches upon the ureter, whether by extension or pressure, that its function is seriously handicapped or destroyed.

These three classes will be found to include the majority of cases coming under observation. Pathologic conditions associated with calculi, fistulas, etc., are largely of collateral importance. The more commonly employed means for solving the difficulty have been implantation in bowel, bladder, or skin, and uretero-ureteral anastomosis. Nephrectomy of the crippled side should, with justice, be definitely eliminated from the list of restitutorial methods, for the impaired ureter is neither restored nor so transferred that its cloacal functionation may continue; and in addition the kidney, which at this point in the patient's career has but a collateral significance, is ablated. As well might one class an amputation following frac-





ture as a restitutorial measure. Ligation of the proximal end of the ureter with induced hydronephrosis and subsequent cessation of nephric function (corroborated by the experimental work of James <sup>40</sup>) should also be excluded; for while the operative work is obviously less perilous than a primary nephrectomy, the end result is analogous—the patient is deprived of the use of his kidney. But this analogy is not complete, for it is impossible to state the actual effect upon the organism when a kidney is thus abruptly thrown out of functionation and an infection atrium may be found existent at any point between the kidney capsule and the ligature encircling the distal end of its ureter. That the remaining kidney may be seriously crippled,—indeed, absent; that such conditions are all too frequently not ascertained previous to an abdominal operation; that it is most difficult to obtain exact information in the stress of so serious an operative casualty as a cut ureter, when time is priceless, seem to be statements of facts so vitally patent as to demand no further discussion, yet that imperatively indicate restitutorial rather than destructive surgical measures. Of these various restitutorial measures, we are, in this discussion, concerned with but the last,—ureteral anastomosis.

IV. *Methods.*—Consideration of the methods scheduled in Section I. will show that the general plan of procedure does not vary in any vitally essential detail.

In Groups I. and II. apposition of extremities is direct, transverse or oblique, with or without support.

Group III. Apposition of extremities is by direct invagination, with or without splitting of segment, with or without support.

Group IV. Apposition of the extremities by lateral invagination, without support.

In Groups I. and II. Outer, middle and inner coats come into direct contact with their several fellows of the other segment.

In Groups III. and IV. The middle coats do not appose each other, but contact is permitted between the outer sheath

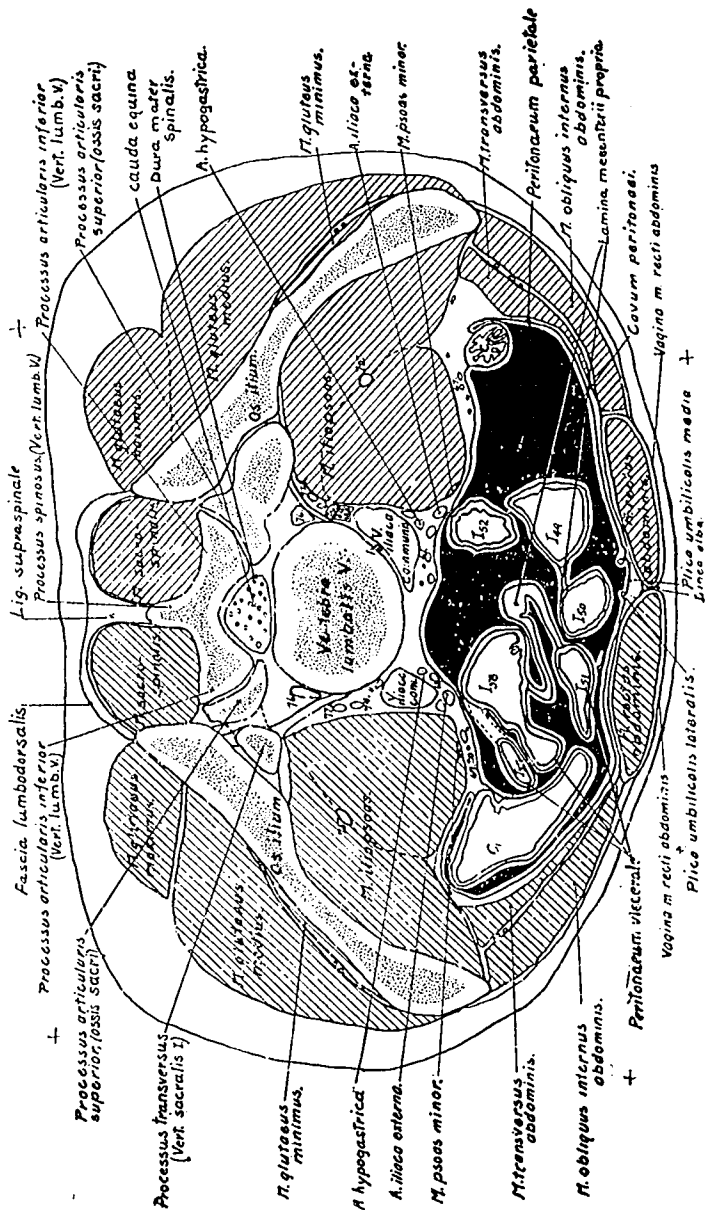


PLATE IV.

of the male segment and the inner coat of the female, save when the outer sheath of the male segment has perchance been liberally scarified,—it then may be assumed that the muscularis of the male segment would be brought in apposition with the intima of the female. A modified Jobert's invagination suture seems to have been most commonly employed.

V. *Personal Work*.—It may be readily conceived that a lateral spinal deflection would so seriously alter ordinary anatomic relations that any one of these excellent methods would prove technically difficult, if not actually impossible.\* And again so large a section of the ureter may be lost, whether as a result of pathologic involvement or surgical intervention, that here also a similar difficulty, or impossibility, would be confronted. With these matters under consideration, and in search of a method that might prove efficacious, in 1900 was devised and performed on two dogs the lateral invagination of the proximal end of one ureter into its fellow. In my "Data of Experiments" this procedure was designated "Intraperitoneal trans-uretero-ureteral anastomosis." The first point to be oriented was, Is the conception an anatomic possibility? the second, Is it a physiologic success? The following notes (heretofore unpublished) show:

*Experiment I*.—Nov. 26, 1900. A small mongrel cur was anesthetized, the left ureter, through a median incision, isolated, divided, the lower segment ligatured and dropped, the upper clamped; the right ureter isolated, a suitable longitudinal incision made, a modified Jobert's invagination suture (fine silk) placed in anterior face of proximal extremity of left ureter, the mesentery perforated close to its root and at an appropriate level, and the left ureter drawn through the longitudinal incision of the right, by means of the two suture ends which were then caused to transfix the three coats of the right ureter below the lower angle of the longitudinal

---

\* Cognate to these personal statements are the observations of Bologna (III Cong. Dell' Ass. Nazionale dei Med., 1905). Among widespread changes developed concomitant with, or sequent to, a scoliosis, he notes that the kidney also suffers, the one on the invaded side being sometimes laterally compressed between the vertebral column and the chest-walls, while the kidney on the concave side hypertrophies. The contracted psoas may so close the lumen of the ureter as to develop an hydronephrosis.



incision. This suture was tied, also three others, one inserted at the upper angle formed by the junction of the ureters, and two, to snugly close the incision, above the junction, which had been made a trifle too long. The lines of junction were covered by a fold of mesentery appropriately sutured.

No special postoperative occurrences. The dog lived eighteen hours. Autopsy showed a competent anastomosis, with no leakage nor ballooning of either ureter or kidney pelvis; no evidence of peritonitis. There was urine in the bladder. The mercurial manometer showed that the anastomosis suture lines withstood up to a pressure of 60 mm. of mercury, at which point leakage followed.

*Experiment II.*—Dec. 13, 1900. A small mongrel dog was anesthetized and again the proximal end of the left ureter invaginated laterally, through a longitudinal incision, into the right. The technical details of this experiment differed in no essential from those noted in *Experiment I*, save that no additional sutures were required to close the longitudinal incision, and two additional sutures were inserted laterally at the spread of the longitudinal incision, made by the inserted ureter, in order to more snugly approximate the union. The mesentery was sutured over the anastomosis. The dog lived forty-eight hours. Autopsy showed a competent anastomosis with no leakage, nor ballooning of either ureter or kidney pelvis; no evidence of peritonitis. The bladder contained urine. The mercurial manometer showed that the anastomosis suture lines would withstand up to 50 mm. of mercury, at which point leakage occurred.

These experiments were carried out under adverse conditions, in that facilities were not to hand for suitable postoperative care of the dogs. After consideration of the autopsy findings, of which the essentials have been given, both Dr. Budgett (late Professor of Physiology, Medical Department, Washington University), who most kindly assisted me and to whom my thanks are due, and I were strongly inclined to the belief that death followed in both experiments from these conditions rather than from any factor directly attributable to the operations.

*Conclusions.*—I. These experiments have proved that an intraperitoneal trans-uretero-ureteral anastomosis is an anatomic possibility.

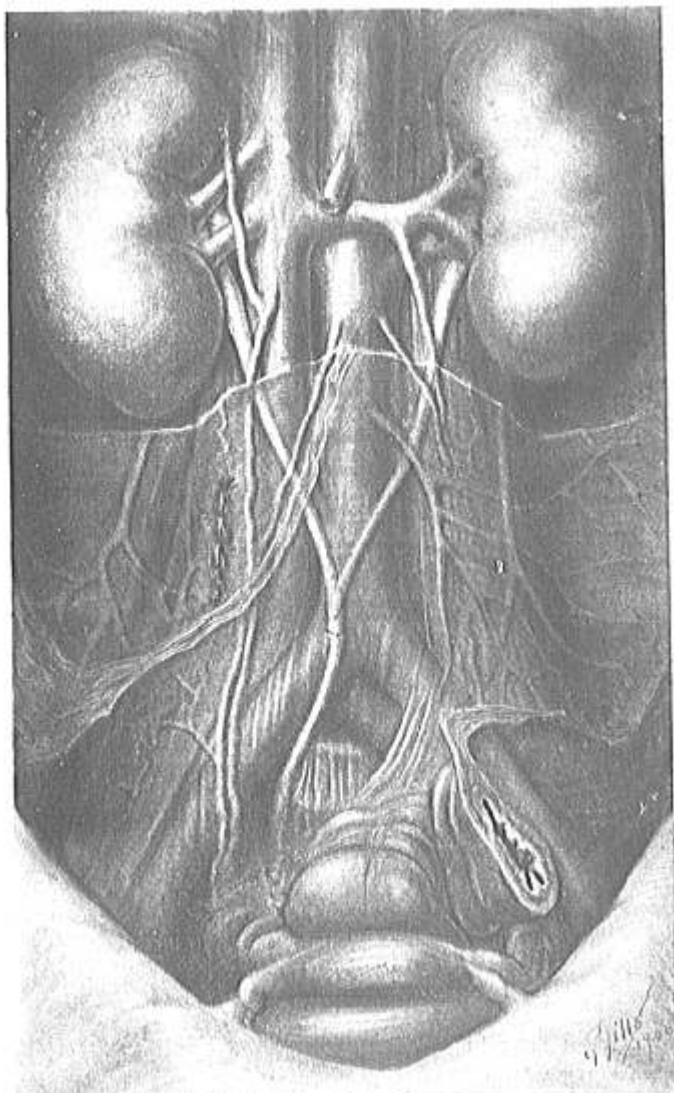
One dog lived eighteen hours, the other forty-eight hours; within these brief periods union sufficient to withstand up to 60 mm. and 50 mm. (mercurial manometer) respectively had been secured. Neither hydronephrosis nor hydro-ureter was

in evidence. Urine was within the bladder. It would seem, therefore, even within the limitations above noted that

II. An intraperitoneal trans-uretero-ureteral anastomosis is a physiologic success.

These experiments were not recorded in the literature and nothing further was attempted along this line of research until March, 1906, when the following procedures were devised and executed on the cadaver. The reasons for altering the above plan of operative attack were, in brief, that it was apparent that if a technique could be constructed that would more nearly protect the ureter from injury and from involvement with other abdominal structures, and in addition conserve and perchance add to its normal blood-supply, a distinct stride in advance would have been measured. These conclusions were based upon a not more than conventional comprehension of the blood-supply of the ureter. They were, however, confirmed when the masterly exposition of the blood-supply of the ureter by Sampson was given to the surgical world. The technical difficulties of the work, hereinafter described, were greatly augmented by the fact that the cadaver subject was not less than eighteen months old and had undergone several periods of drying and moistening, with the result of both tissue rigidity and brittleness.

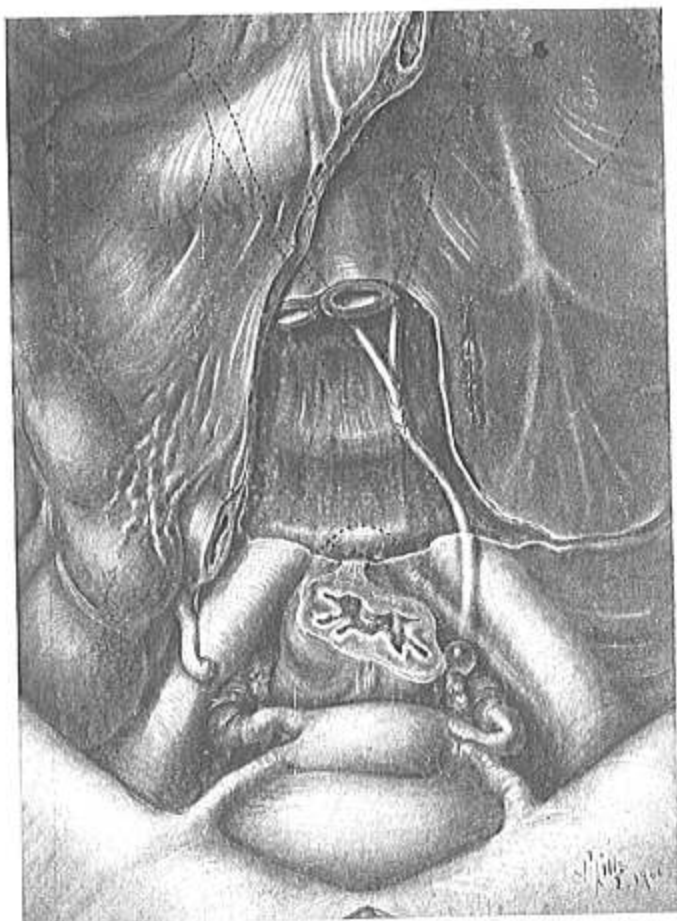
*Experiment III.*—Through the anterior abdominal wall (which had previously been opened in the mid-line) the field was so cleared by laying aside obscuring structures that the courses of the ureters were developed. A suitable longitudinal incision through the peritoneum over the right ureter, and its isolation, above the promontory of the sacrum, were made. Retracting the ureter laterally, a retroperitoneal dissection, largely by the finger, but assisted occasionally by the handle of a scalpel, was made toward the mid-line, penetrating in the layer of connective tissue between the inferior vena cava and aorta posteriorly and the peritoneum anteriorly, until the left ureter was reached and identified. After liberating this for a sufficient distance it was brought across to its fellow, incised, the distal extremity released, and a lateral invagination through a longitudinal incision in the right ureter was made as detailed in Experiments I. and II. When the anastomotic area was released and the peritoneal edges of the longitudinal incision approximated, the entire field of manipulation was found to be wholly retroperitoneal. The difficulty of accomplishment was not excessive, and the ureters showed no evidence of undue tension.



**PLATE VI.**—Retroperitoneal trans-uretero-ureteral anastomosis. Anterior to aorta and vena cava.

A tendency for the sound ureter to approach the mid-line is to be noted; this is due in part to its new attachment to its fellow, in part to its segmental release from its original bed. The distal stump of the left ureter is not shown. Peritoneum has been removed over the kidney, but portrayed transparent over anastomotic area.





**PLATE VII.**—Retroperitoneal trans-uretero-ureteral anastomosis. Posterior to aorta and vena cava.  
 Peritoneum, aorta, and vena cava removed to show ureters and their relation to vertebral column. The distal stump of the right ureter is not shown.

Experiment III. proved that a retroperitoneal trans-uretero-ureteral anastomosis is an anatomic possibility.

Realizing, however, that a more direct route might be available, and that various conditions, such as a lodosis or a relatively extreme depth of the lateral abdominal fossæ, would make such a route highly valuable, the following procedure was performed:

*Experiment IV.*—The sutures of the above noted anastomosis were liberated and the two ureters replaced in their normal positions. Through the same longitudinal incision over the right ureter a dissection was made toward the mid-line and passing between the vertebral column posteriorly and the vena cava and aorta anteriorly the left ureter was reached and again withdrawn to its fellow, and again invaginated in the existing longitudinal incision by the method followed in the former efforts. When the anastomotic area was released and the peritoneal edges of the longitudinal incision approximated, the entire field of manipulation was found to be wholly retroperitoneal. In this instance, also, the difficulty of accomplishment was not excessive. It was also readily seen that owing to the shorter route traversed the ureters, whose liberated areas had not been extended over those of Experiment III., had gained demonstrable laxity.

While retroperitoneal trans-uretero-ureteral anastomosis, whether anterior or posterior to vena cava and aorta, is admittedly more difficult of accomplishment than intraperitoneal trans-uretero-ureteral anastomosis, yet it must be conceded that owing to the shorter hiatus to be bridged, with proportionately less disturbance of the ureters and their blood-supply, their probable subsequent vitality and power of functionation are enhanced in conformity with the postulates of Sampson. It is also probable that owing to the replacement of the ureters within beds which are closely allied to, if not in fact actually identical with, their normal surroundings, the interference with their blood-supply will be reduced to the minimum; and the possibility of nourishment to be derived from contiguous connective tissue and the peritoneal covering must not be ignored.

Beyond the technical difficulties inherent to such manipulations, and the necessary time involved, possibly superimposed upon other operative measures (both of which may, however,

be diminished by practice), the query which will, in all probability, most readily spring to the mind is, whether or not sufficient pressure will be exerted by the aorta and vena cava to materially interfere with the patency of the transferred ureter (or the anastomotic area itself, if it should happen to be the point in contact). It is conceded that Experiments III. and IV. prove merely the anatomic possibility of a retroperitoneal trans-uretero-ureteral anastomosis, respectively ante-aortic and ante-vertebral. Suitable material has not as yet been secured for demonstrating if these procedures be physiologic successes. But in support of such an hypothesis may be adduced the well-known physiologic fact that a tube with well-defined mural structure which exhibits an intratubular pressure, whether constant, periodic or occasional, is able to maintain its patency though extramural pressure be maintained. The rectum clamped between the sacrum and an augmenting pelvic fibroid is a fairly familiar example; the vena cava and the left common iliac vein fixed between the vertebral column and the aorta and right common iliac artery, is another. These examples are specially interesting, for in the former an intratubular pressure exists only during evacuation of, or when the rectum is filled with, *fæces*; and in the latter it is known that dependent largely upon intrathoracic conditions the intracavitary pressure varies from an actual negative to but a few millimetres of mercury, while the diastolic and systolic aortic pressures presumably somewhat exceed the brachial pressures, which are 75 to 100 and 100 to 150 mm. respectively. In other words, the patency of a compressed tube may remain even though the constricting force be in excess of its own intratubular pressure. The intraureteric pressure reaches 60 mm. of mercury, beyond which an hydro-nephrosis threatens.

While from a purely controversial standpoint it might be inopportune to allude to the increase of ureteric pressure which follows when a constricting force is permitted to exert itself, yet clinically we are compelled to concede that this increase of intratubular pressure but enhances the probability of maintenance of patency.

In the final survey of the literature of ureteral surgery before closing this article, it was discovered that the proceedings of Experiments I. and II. carried out independently by myself in November and December, 1900 (not hitherto recorded), had been in all essentials paralleled by the following workers:

1894. BOARI and CASATI<sup>31</sup> tried uretero-ureteral anastomosis on the dog on eight occasions. The mesosigmoid was perforated; approach was gained both by the anterior abdominal route and also a lateral extraperitoneal route, of which close details are lacking. All dogs, save one, died within two or three days after operation. This one died from peritonitis with urinary infiltration on the eighth day. The anastomosis had yielded at one point.

1895. MONARI<sup>32</sup> followed the same method on the dog 13 cm. from the bladder. "At the end of a certain time," the dog was killed; stenosis of the ureter at point of penetration of the mesosigmoid found; no stenosis at site of anastomosis; hydro-ureter and ballooning of the kidney pelvis existed. He concludes that the operation may be made in man, in certain cases of urinary fistulas, in place of more serious procedures, and that no danger would follow if the ureter be replaced in "its fatty capsule."

1896. WISSINGER<sup>33</sup> presented before the Medical Society of Hamburg "a beautiful specimen," but so far as the literature shows failed to mention either source or method.

1905. FREUND<sup>34</sup> records that he implanted, in a bitch, the proximal end of an ureter in a fallopian tube; the other end of the tube was then connected with the bladder. Mention is made that a similar plan was followed by D'Urso and de Fabii. After stating that transureteral anastomosis had been suggested as a possibility by Kelly, McMonagle and Sampson, he describes having cut a ureter in a dog; its central end was drawn by ligatures through the mesentery, and laterally attached by two sutures to its fellow; six silk sutures were utilized in completing a lateral anastomosis.

1905. BERNASGONI and COLUMBINO<sup>35</sup> performed uretero-ureteral anastomosis on ten dogs, both near the bladder and in the lumbar region. They believed that they were the first to successfully penetrate the mesentery. They direct attention to the fact that in the dog so loose is the posterior peritoneum that the ureter is furnished with what is practically a mesoureter; this, in particular, holds in the vicinity of the bladder. Eight of their cases were near the bladder, lateral implantation between two retention sutures; continuous sutures were employed, which were covered by a Lambert of the peritoneum. Three dogs died; five perfect results determined at end of three to four months. Two cases were transmesenteric at height of the umbilicus; ureters were found over the psoas, and anastomosis was made by the former method, save that the

mesentery was perforated. The first dog died of peritonitis on eighth day; no leakage noted. The second survived. Autopsy at three months; result excellent.

So far as known the work detailed in Experiments III. and IV. has not been duplicated.\*

VI. *Chronology*.—The following chronologic table of the development of the surgery of the ureter outlines in sequence the rather more essential steps that have led up to the present-day work in uretero-ureteral anastomosis. It also includes the latest experimental work, so far as known:

- 1851. *Simon*.—Extraperitoneal uretero-rectal anastomosis.
- 1876. *Nussbaum*.—Extraperitoneal uretero-rectal anastomosis.
- 1879. *Smith*.—Extraperitoneal uretero-rectal anastomosis.
- 1886. *Schopf*.—Transverse, end to end, without support.
- 1886. *Poggi*.—Invagination, end within end, without support.
- 1892. *Van Hook*.—Invagination, lateral, without support.
- 1894. *Boari and Casati*.—Intraperitoneal trans-uretero-ureteral anastomosis,—dog.
- 1895. *Monari*.<sup>1</sup>—Same method,—dog.
- 1897. *Bovée*.—Oblique end to end.
- 1900. *Sharpe* (Nov. and Dec.).—Intraperitoneal trans-uretero-ureteral anastomosis; lateral invagination,—dog.†
- 1905. *Freund*.—Implanted the proximal end of ureter in a Fallopian tube. The other end of tube was then implanted in the bladder. (States that D'Urso and de Fabii had also accomplished the same.) In addition records a lateral intraperitoneal trans-uretero-ureteral anastomosis,—dog.
- 1905. *Bernasconi and Columbino*.—Intraperitoneal trans-uretero-ureteral anastomosis,—dog.

---

\* I desire to acknowledge, with appreciation, the courteous assistance and valuable coöperation, tendered me by Dr. Robert J. Terry and Dr. Vilray P. Blair, respectively Professor of Anatomy and Associate Professor of Anatomy in the Medical Department of Washington University.

† Not hitherto published.

1906. *Sharpe* (March).—Retroperitoneal trans-uretero-ureteral anastomosis, lateral invagination,—cadaver.

(a) Anterior to aorta and vena cava, posterior to peritoneum.

(b) Anterior to vertebral column. Posterior to aorta and vena cava.\*

## VII. *Conclusions.*—

I. The blood-supply of the ureter is ample, of which probably the peri-ureteral arterial plexus is the most essential factor.

II. Operative procedures which conserve the blood-supply, in particular the peri-ureteral arterial plexus, are ordinarily satisfactory.

---

\* Of very great interest, in connection with the problems incidental to wounded ureters or such other conditions that may tempt the operator to find a solution in a nephrectomy, is the work of Carrel, Floresco and others in organ-transplantation. They have most ingeniously devised and successfully executed plans by which the kidney, heart and other organs, removed from their normal site and transplanted elsewhere, have continued functionation. The three natural subdivisions of auto-transplantation, homo-transplantation and hetero-transplantation—have received consideration and experimental work is of record. This suggestive research is pregnant with possibilities for future development. For details see:

*Carrel.* La technique opératoire des anastomoses vasculaires et la transplantation des viscères. Lyon Medical, 1902.

*Carrel.* Les anastomoses vasculaires; leur technique opératoire et leurs indications. Le Congrès des Médecins de la langue Française de l'Amérique du Nord. Montreal, 1904.

*Floresco.* Conditions de la transplantation du rein. Recherches sur la transplantation du rein. Jour. de Physiol. et de Pathol. générale, 1905.

*Carrel and Guthrie.* Functions of a Transplanted Kidney. Science, October 13, 1905.

*Carrel.* Transplantation of Organs. Jour. Am. Med. Assn., 1905, vol. xlv, p. 1645.

*Carrel et Morel.* Anastomose bout à bout de la jugulaire et de la carotide interne. Lyon Médical, 1902, v. 99, p. 114.

*Carrel et Morel.* Presentation d'un chien, porteur d'une anastomose artérie veineuse. Lyon Médical, 1902, v. 99, p. 153.

*Carrel.* Anastomosis and Transplantation of Blood-vessels. American Medicine, 1905, August.

*Carrel and Guthrie.* The Reversal of the Circulation in a Limb. ANNALS OF SURGERY, 1906, v. xliii, p. 203.

III. When the integrity of the ureter is impaired, restitutive rather than destructive surgical measures should be followed.

IV. Of which restitutive measures the various methods of uretero-ureteral anastomosis are recommended.

V. Intraperitoneal trans-uretero-ureteral anastomosis is an anatomic possibility; it is also a physiologic success.

VI. Retroperitoneal trans-uretero-ureteral anastomosis, whether anterior or posterior to the aorta and vena cava, is an anatomic possibility. (Further experimentation is essential in order to prove that it is a physiologic success.) The route followed is the shortest path between the two ureters. The technical difficulties are not excessive. It is highly probable that this method impairs the ureteric blood-supply less than any other method in vogue.

#### REFERENCES.

- <sup>1</sup> QUAIN. *Anatomy*, 1896, Vol. iii, p. iv, 205.
- <sup>2</sup> MORRIS. *Surgical Diseases of the Kidney and Ureters*, 1901, Vol. ii, 284.
- <sup>3</sup> DISSE. *Von Bardeleben, Handbuch der Anatomie*, 1902, Bd. vii, Th. 1, S. 110.
- <sup>4</sup> CUNNINGHAM. *Text-Book of Anatomy*, 1905, p. 1088.
- <sup>5</sup> PROTOPOPOV. *Beiträge zur Anatomie und Physiologie der Ureteren*. *Arch. f. die Gesam. Physiologie*, 1897, lxvi, 21.
- <sup>6</sup> FREUND UND JOSEPH. *Ueber die Harnleiter-Gebärmutter-fistel nebst neuen Untersuchungen über das normale Verhalten der Harnleiter im Weiblichen Becken*. *Berlin. klin. Woch.*, 1869, vi, 508.
- <sup>7</sup> HOLL. *Zur Topographie des Weiblichen Harnleiters*. *Wien. med. Woch.*, 1882, xxxiii, 1326, 1458.
- <sup>8</sup> TANDLER AND HALBAN. *Topographie des Weiblichen Ureters*, 1901.
- <sup>9</sup> MARGAROUCCI. *Ricerche sulla circolazione propria dell' Uretere*. *Il Policlinico*, 1894, n. 15.
- <sup>10</sup> MONARI. *Ueber Ureter Anastomosen*. *Beiträge zur klin. Chirurg.*, 1896, xv, 722.
- <sup>11</sup> WALDEYER. *Das Becken*, 1899, S. 420.
- <sup>12</sup> FEITEL. *Zur arteriellen Gefäss-Versorgung des Ureters, insbesondere der Pars pelvina*. *Zeits. zur Geb. und Gyn.*, 1901, xlv, 269.
- <sup>13</sup> SAMPSON. *Johns Hopkins Hosp. Bull.*, v. xv, 39.
- <sup>14</sup> SAMPSON. *Johns Hopkins Hosp. Bull.*, v. xv, 72.
- <sup>15</sup> KÜSTER. *Archiv für klin. Chirurg.*, 1892, xlv, 850.
- <sup>16</sup> MYNTER. *ANNALS OF SURGERY*, 1893, Dec.
- <sup>17</sup> FENGER. *ANNALS OF SURGERY*, 1894, xx, 257.
- <sup>18</sup> PARVIN. *Western Jour. of Medicine*, 1867, II, 603.
- <sup>19</sup> EMMET. *Gynæcology*, 1880.

- <sup>10</sup> SAMPSON. American Medicine, 1902, iv, 693.
- <sup>11</sup> SAMPSON. Johns Hopkins Hosp. Bull., 1902, xiii, 299.
- <sup>12</sup> SAMPSON. Johns Hopkins Hosp. Bull., 1904, xv, 39, 72, 123.
- <sup>13</sup> SCHOPF. Allgem. Wien. med. Zeit., 1886.
- <sup>14</sup> SCHOPF. Centralbl. für Gynäk., 30, 1887.
- <sup>15</sup> MARKOE AND WOOD. Uretero-ureteral Anastomosis for Traumatism  
ANNALS OF SURGERY, 1899, v. xxix, 693.
- <sup>16</sup> BOVÉE. ANNALS OF SURGERY, 1897, v. xxvi, 318.
- <sup>17</sup> FREUND UND JOSEPH. *Loc. cit.*
- <sup>18</sup> LUSCHKA. Topographie des Harnleiter des Weibes. Archiv für Gyn.,  
1872, iii, 378.
- <sup>19</sup> HOLL. *Loc. cit.*
- <sup>20</sup> WALDEYER. Ureter-Scheide. Verhandlungen der Anatomischen Gesellschaft, 1892, 259.
- <sup>21</sup> SAMPSON. Johns Hopkins Hosp. Bull., xv, 40.
- <sup>22</sup> MARGARUCCI. *Loc. cit.*
- <sup>23</sup> DURANTE. Bolletino della R. Accademia medic di Roma, xv, 59.
- <sup>24</sup> BOARI ET CASATI. Contributo sperimentale alla plastica dell uretere  
(Comunicazione all Accademia delle Scienze Med. et Nat. di Ferrara  
Maggio, 1894).
- <sup>25</sup> MONARI. (a) Uretero-anastomosi. Ricerche sperimentali. Bologna: R.  
Tipographia, 1895. (b) Beiträge zur klin. Chirurg., 1896, T. xv.
- <sup>26</sup> WISSINGER. Berlin. klin. Woch., Nov. 16, 1896, 1033.
- <sup>27</sup> FREUND, R. Zur Ureteren-chirurgie. Verhand. Deutsch Gesellschaft für  
Gyn., 1905, p. 492.
- <sup>28</sup> BERNASGONI ET COLUMBINO. Ann. des Mal. des Organ. Urin., Sept. 15,  
1905.
- <sup>29</sup> POGGI. Guérison immédiate des sections transversales des Urétères sans  
oblitération de leur cavité. Riforma Medical, 1887, p. 53.
- <sup>30</sup> JAMES. Physiological and Clinical Study, Edinburgh, 1888, p. 49.